HCal Light Collection Efficiency Correction Simulation Study

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Detector Configuration

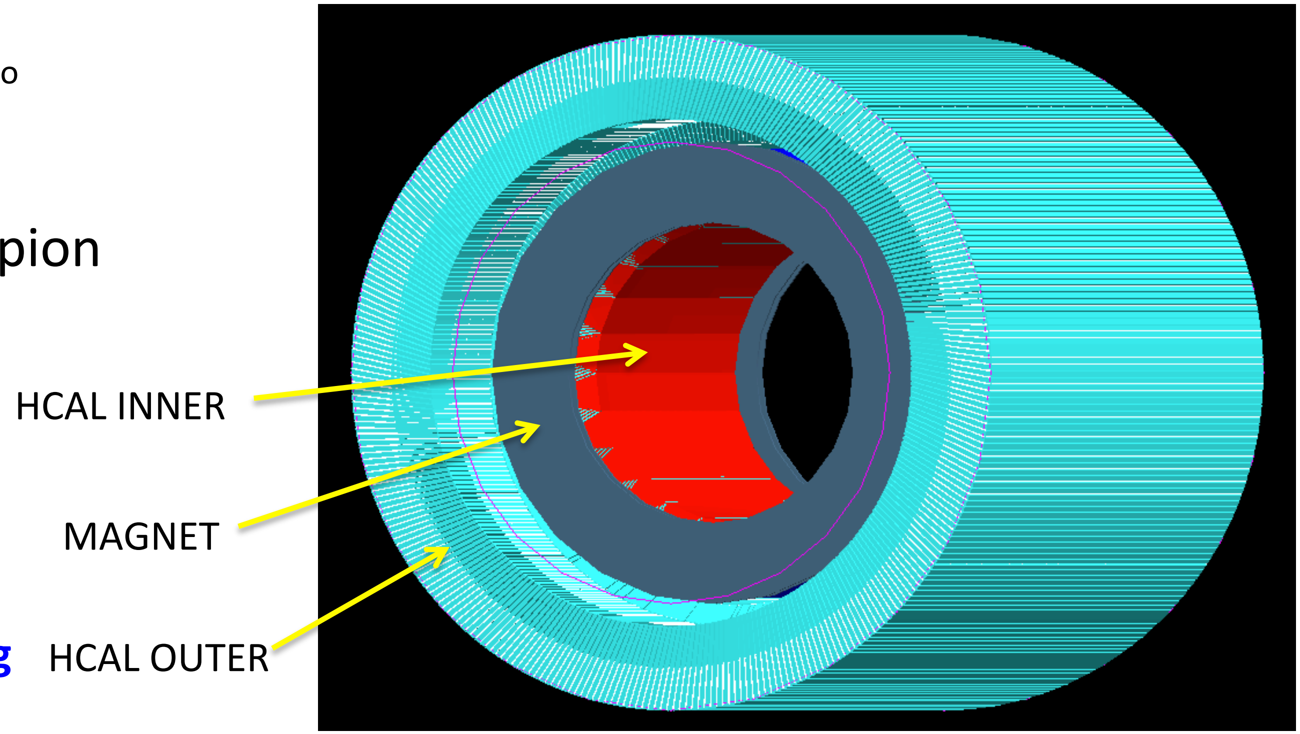
- Inner HCal + Magnet + Outer HCal
- Inner HCal:
  - Scint tile / Stainless steel
  - R(in)=116 cm, R(out)=135 cm
  - Scint thickness: 0.7 cm, # Scint tiles: 64x5
  - Tilted-angle: 29.4^{o}
- sPHENIX field map
- 5 k, 30 GeV charge pion

- Outer Hcal:
  - Scint tile / Fe
  - R(in)=178 cm, R(out)=260.3 cm
  - Scint thickness: 0.7 cm, # Scint tiles: 64x5

HCAL Reference Design

New sPHENIX software

Pure G4Hit, ideal towering



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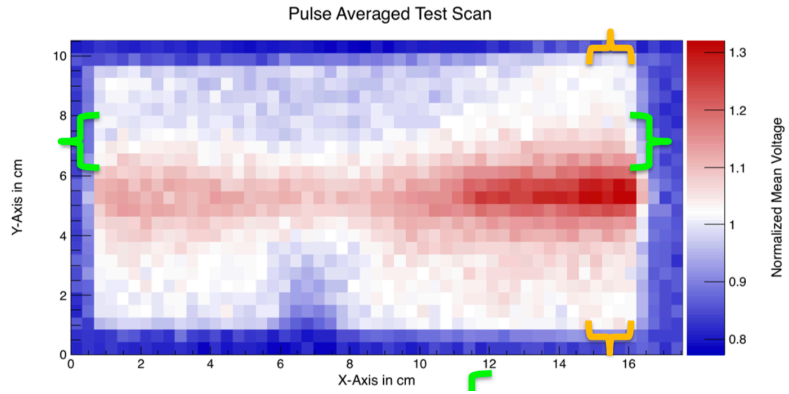
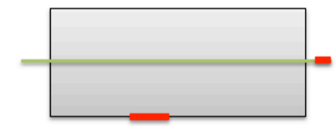
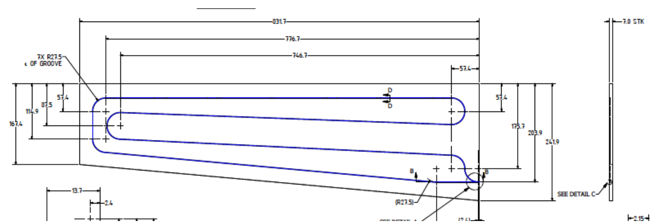
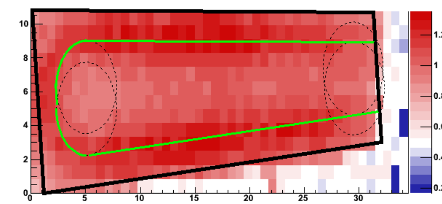
Light Collection Efficiency

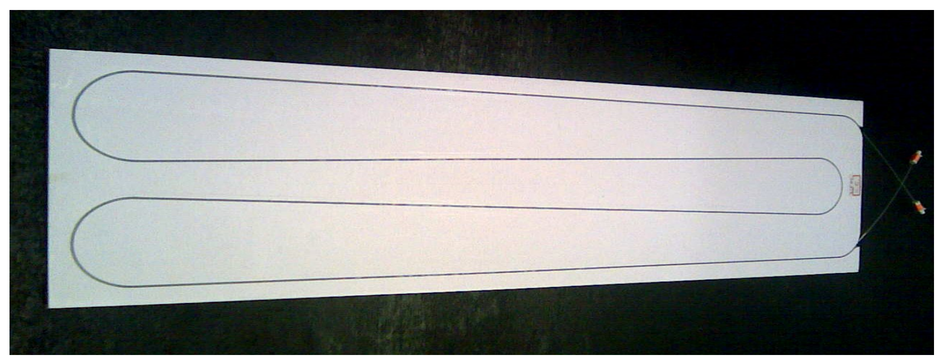
- Previous study assume a uniform light collection efficiency.
- Light collection efficiency is different for photons at different position of the scintillator tile.
- A linear light collection efficiency correction is applied by assuming Eff(outer radius)=1.0, and Eff(inner radius)=0.4 for outer HCAL, Eff(inner radius)=0.85 for inner HCAL











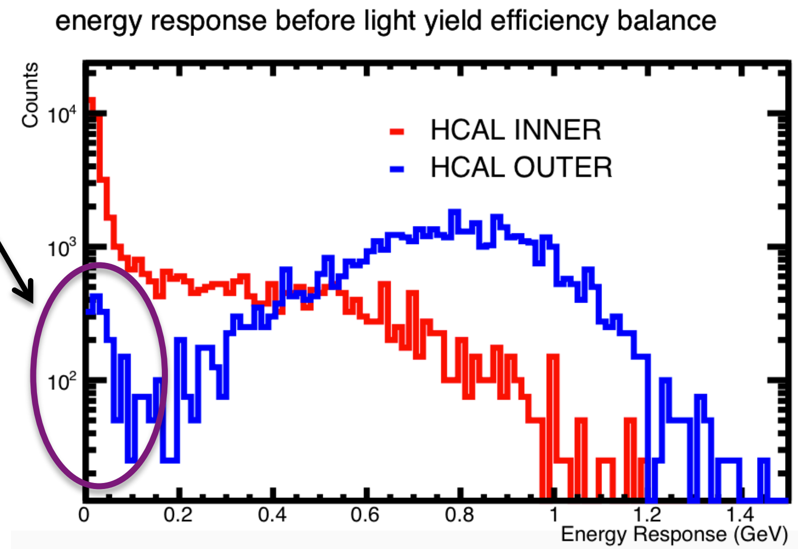
$$eff = \frac{1.0 - 0.4}{R_{out} - R_{in}} \times (r - R_{in}) + 0.4$$

E. Kistenev

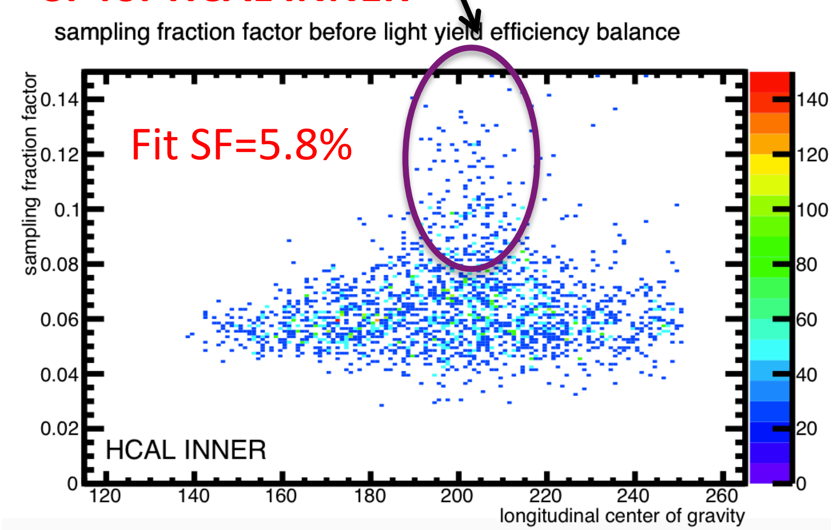
Energy response, sampling factors before light correction

- A spike (channeling / punch through) at 0 for energy response in HCAL outer.
- HCAL inner has a larger SF tail; No distinct decrease trend for SF vs. longitudinal center of gravity (LCG) for HCAL inner.
- HCAL outer SF is dependent on LCG/radius (decrease trend) as expected.

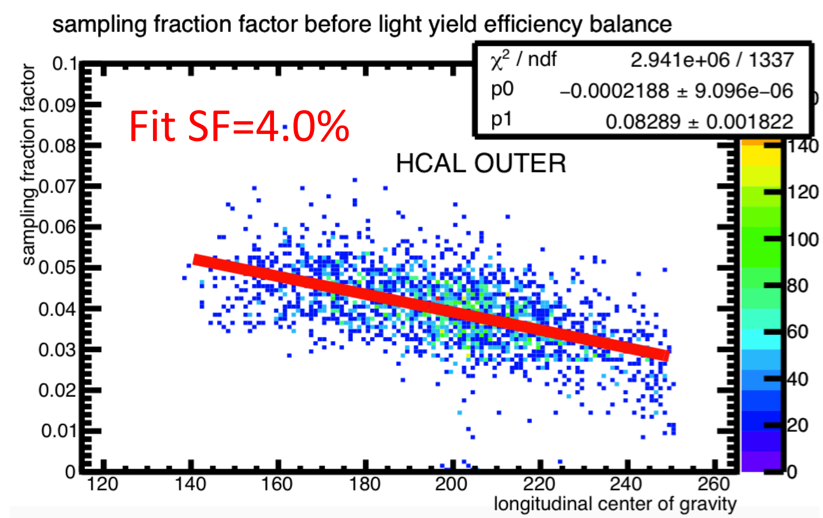
Before Light Eff Correction



SF for HCAL INNER



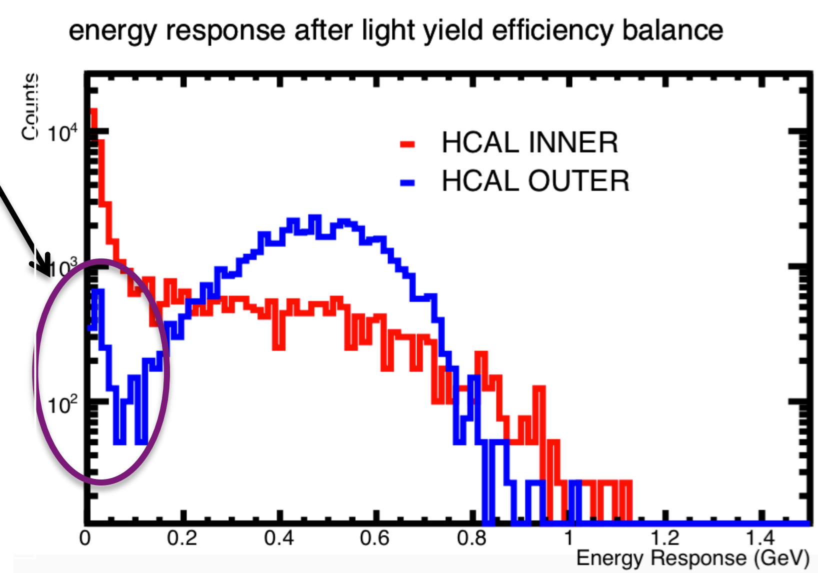
SF for HCAL OUTER



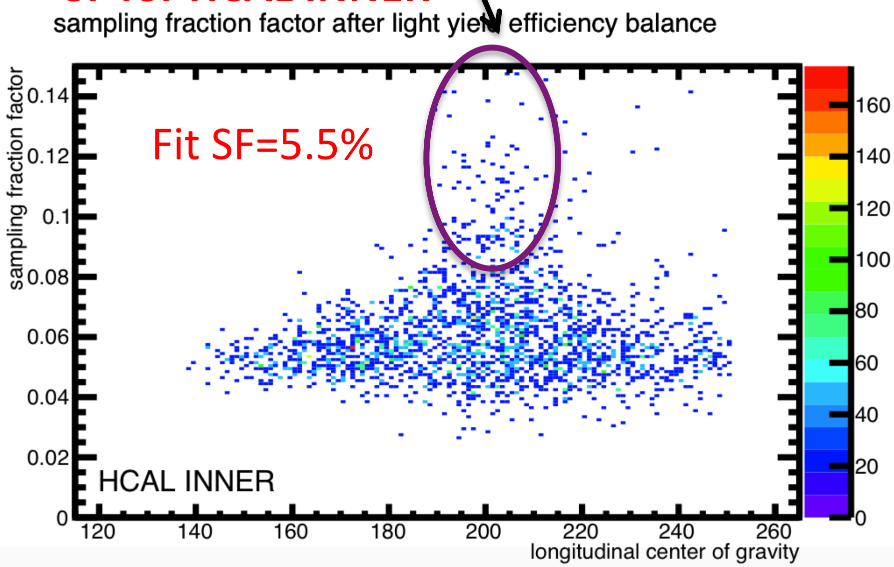
Energy response, sampling factors after light correction

- A spike (channeling / punch through) at 0 for energy response in HCAL outer.
- HCAL inner has a larger SF tail; No distinct decrease trend for SF vs. longitudinal center of gravity (LCG) for HCAL inner.
- HCAL outer SF vs. LCG dependence is removed after light efficiency correction.

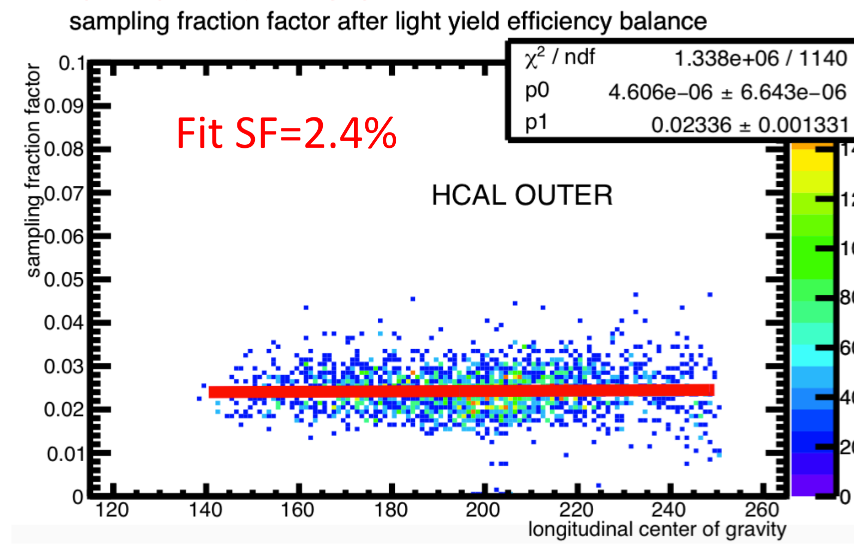
After Light Eff Correction



SF for HCAL INNER

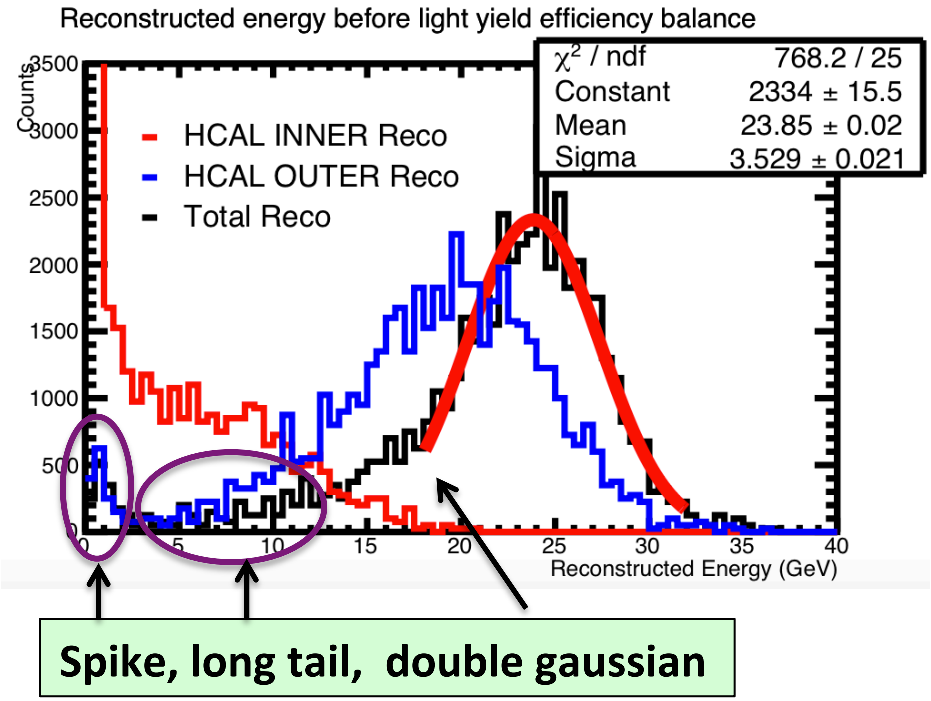


SF for HCAL OUTER

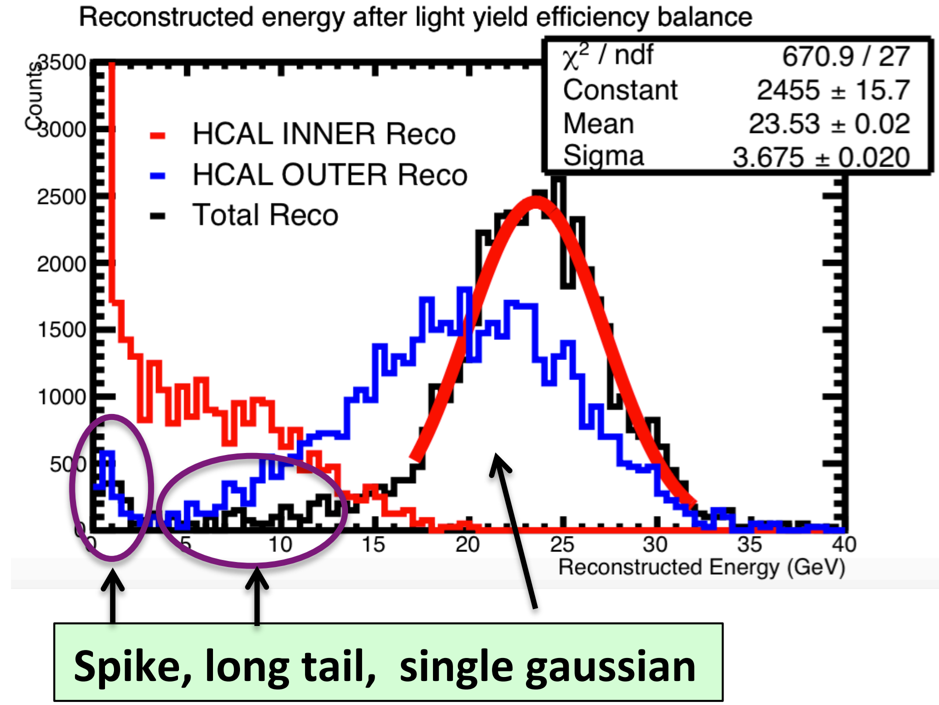


Reconstructed energy before/after light correction

Before Light Eff Correction

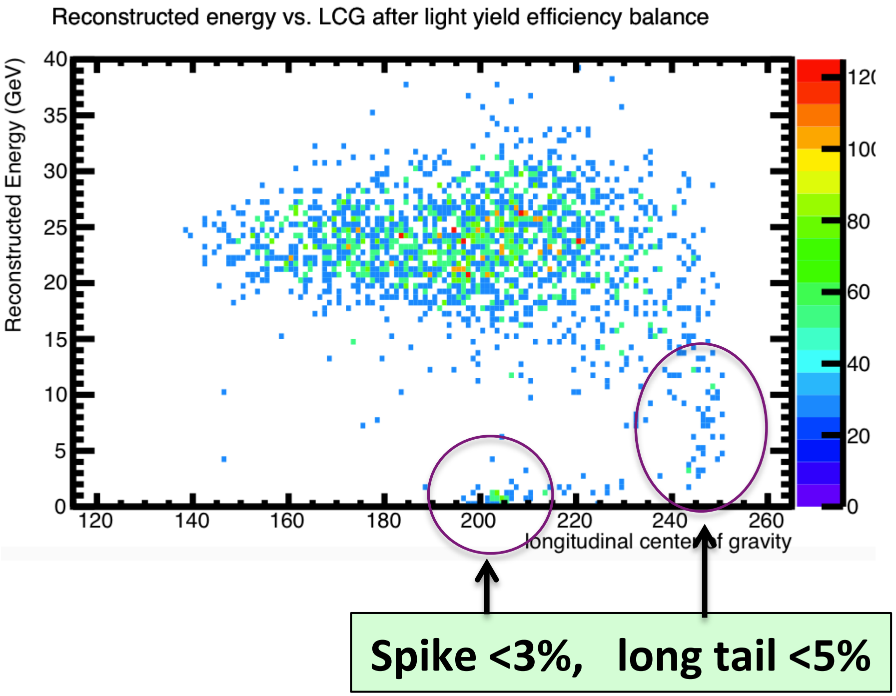


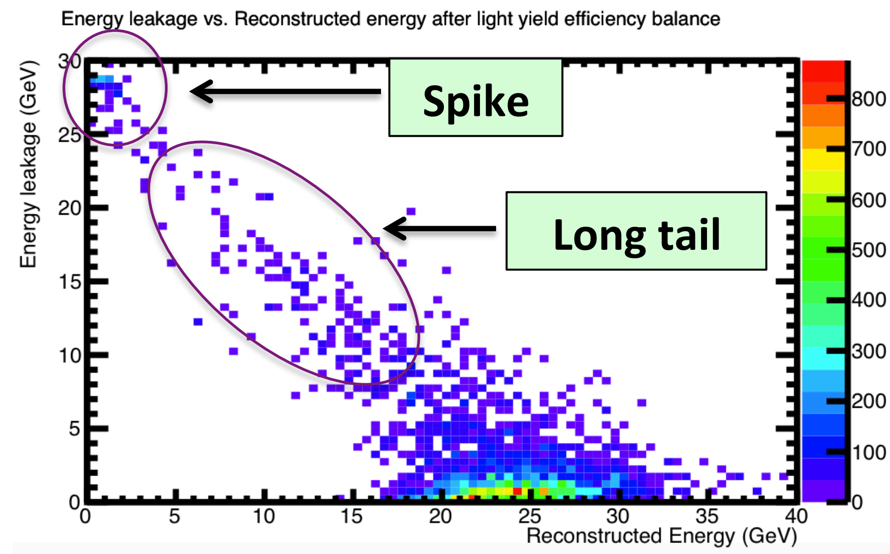
After Light Eff Correction

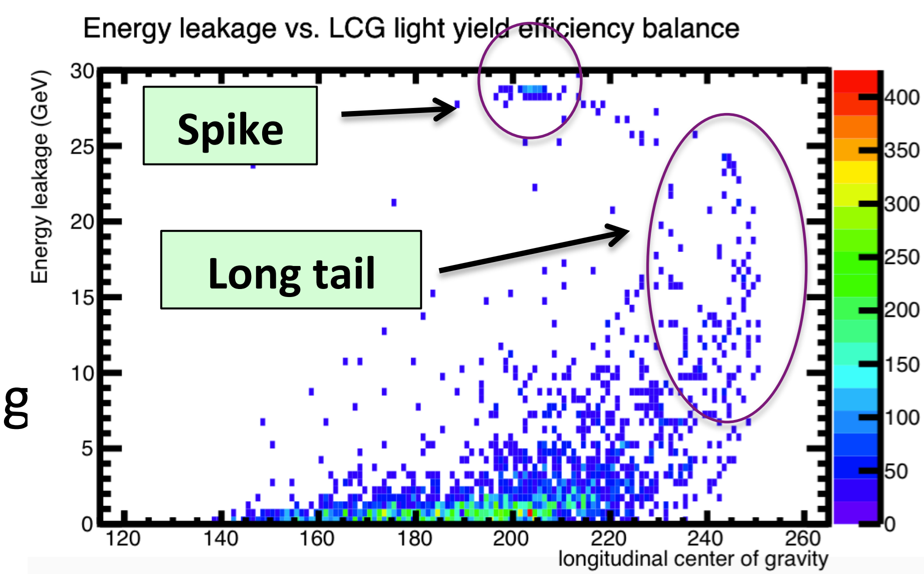


- Energy resolution (fitted sigma) does not change much.
- The spike at 0 (channeling / punch through **<3% with E < 3 GeV**), long tail (energy leakage, <5% with cut **3 GeV < E < 14 Ge**V) persists after light correction.
- Light correction does eliminate the double gaussian structure that exists before correction.

Spike, lower side tail of energy spectra







- Spike at 0 due to channeling / punch through is <3% with E<3GeV.
- Low side tail due to energy leakag of deep hadronic shower is <5% with cut 3 GeV <E< 14GeV.

Summary

- Light collection efficiency correction is studied with 30 GeV pion for sPHENIX reference design.
- Light correction with Eff(outer radius)=1.0, and Eff(inner radius)=0.4 for outer HCAL can remove the SF dependence on LCG/radius.
- Particle channeling/punch through is <3%, and low side tail due to energy leakage is <5% for 30 GeV pion.